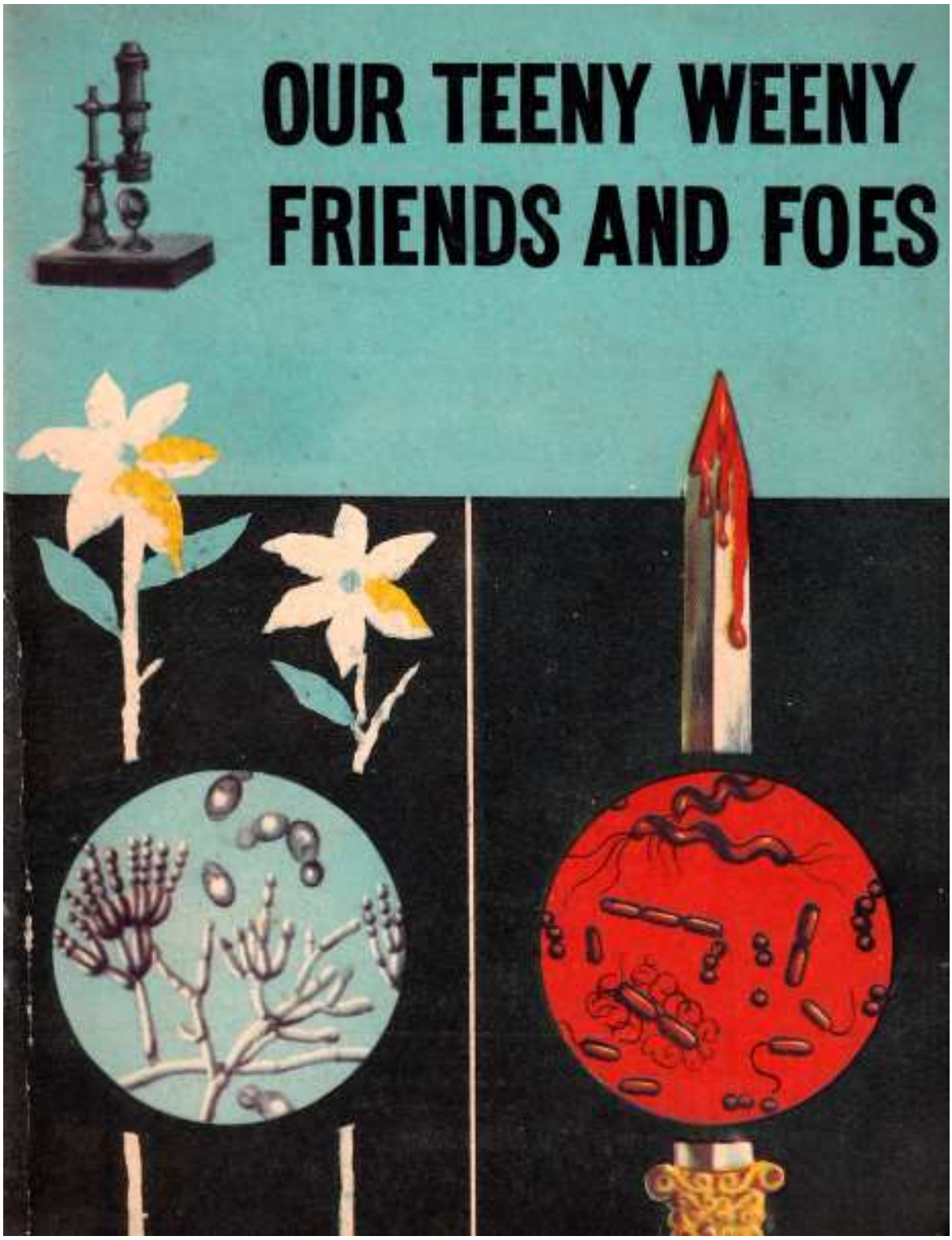

OUR TEENY WEENY
FRIENDS AND FOES

CITIZENS OF TOMORROW SERIES 3

First Published : 1968

Second Edition : 1968

Third Edition : 1969

This booklet was written for Somaiya Publications by Mr SOLI PAVRI. This edition has been revised and slightly enlarged by the Somaiya editorial staff.

Illustrated by SURENDRA SIRSAT

Rs. 1.80

SOMAIYA PUBLICATIONS PVT LTD
172, Naigaum Cross Road, Dadar, Bombay 14 DD

Printed by S N Tavkar, Somaiya Publications Pvt Ltd (Printing Unit), Wadala Udyog Bhavan, Bombay 31, and Published by G B Newalkar, Somaiya Publications Pvt Ltd, Bombay 14

1. Dr. Shah and His Japanese Guests

LITTLE John Ikoma and his dad were the guests of Dr. Ratibhai Shah. The Ikomas were a Japanese family of merchants who had come to India on a business tour. The Ikomas while visiting the Jain temples as tourists were wonderstruck by their beauty.

"Ah, look Daddy," said little John pointing to a Jain sadhu wearing a mask over his mouth, "that man is suffering from a cold or a cough."

Dr. Shah, who was surprised to hear little Ikoma say that, exclaimed, "But how on earth can you say that? I am very sure he isn't suffering from either a cold or a cough."

Mr. Ikoma, realising what his son meant, laughed. He said, "Well, it's like this: In Japan a citizen who suffers from a cold or a cough wears a mask over his mouth to prevent others from catching cold."

"Oh, how thoughtful the Japanese are!" exlaimed Dr. Shah. "Anyway, the Jain sadhu you see wears this mask for another reason. He wants to respect life in every form."

. . . . "But of course," said Mr. Ikoma, "you doctors wear similar masks, don't you?"

" Yes, we do," replied Dr. Shah, "particularly when we perform operations, and when these take place, everyone with the doctor, whether nurses or any of the other attendants—all have to wear them."

"Why do you doctors and nurses were these masks?" asked little John.

The learned doctor replied, "Doctors wear masks particularly to protect the sick man on the operation table against the danger of infection with the tiny germs which they breathe out. These germs are likely to get into the open wound and so to protect the patient they cover their mouths and noses with such masks."

"Yes, I remember," said John, "our teacher too wants us to cover our mouths and noses with handkerchiefs when we sneeze or even cough."

"That's right," said Dr. Shah, "that must be done. I can show you a photograph of the teeny weeny germs that fly out of a man's nose when he sneezes. These tiny things cannot be seen with our naked eye. You require an instrument which can make things look many times bigger."

"Like grandpa's thick glasses?" asked John.

"Well, very much so," said Dr. Shah, "these magnifying glasses or lenses fixed in a tube, together with other complicated mechanisms, make what we call a microscope. So wonderful is this instrument that with it a new world has been opened up to scientists. It is a world full of a thousand different kinds of tiny beings or living things. Some of these are very dangerous and deadly, others are friendly and useful.

"But where do we find them?" asked John.

"Where!" exclaimed Dr. Shah, "Rather ask me: where not! We find them everywhere! All objects that are exposed to air are covered with these

tiny living things. Take your skin, for example. It is completely exposed to air and it is said that there are more tiny creatures on its surface than there are people in the world."

"But where in our body do we find them the most?" asked Mr. Ikoma.

"They are mostly found in our food canal, right from the mouth to the end of the intestines, where they make their homes. There is a name given to these tiny things. We call them MICROBES. 'Micro' means very, very tiny—so tiny that we can see them only through the microscope. Most of them are called by a special name BACTERIA which in the Greek language means 'little rods' (named thus because of their rod-like shape). The scientists who study them are called BACTERIOLOGISTS. These men and women, who have made a deep study of these tiny living things, say that these microbes may be plants or animals. Indeed, they are so numerous that, in their opinion, even the pages of the book you read are covered with bacteria."

"If that is so, we should all be dead because of these dangerous germs," said Mr. Ikoma.

"Ah, Mr. Ikoma, that's what people think. We must remember that all

microbes are not germs. True, this very moment there are microbes living happily in my body and yours, but they do no harm at all. In fact most microbes are harmless and many are even helpful. Indeed, if there were no microbes in our intestines, we would suffer from indigestion. These microbes, or micro-organisms as they are called, actually help in the process of digestion."

"But tell me, doctor, how does one learn all about microbes?" asked little John.

Dr. Shah saw the serious, earnest little face before him, and asked, "Would you really be interested in knowing more about microbes?" And, without waiting for an answer, he continued, "Well, because you are so interested in the subject, I'll give you a book to read."

"O doctor! Thank you! I'll return the book as soon as I've done with it," said John.

"No," said Dr. Shah, "you may keep the book; that's a gift from me to a future doctor, eh?"

2. Leeuwenhoek — The Father of the Microscope

JOHN Ikoma eagerly opened the book Dr. Shah had presented to him. It was called ***Our Teeny Weeny Friends and Foes***. He was by himself in his room and the following are the chapters of the book he read with increasing interest. The first chapter told him of a Dutchman who was called crazy. This is what he read:

It was 1632 and the world was full of people who were both ignorant and superstitious. It was in this period that our scene is set in Delft—a city in

Holland. In a family of basket weavers was born a boy who later became a cloth merchant and town councillor. He was truly a clever Dutchman who developed a keen interest in grinding lenses. His name was Anthony van Leeuwenhoek (pronounced Lu-wen-hook). His hobby taught the world that our universe is inhabited by many more than we once believed it to be. Let us see how he did it.

Leeuwenhoek had heard how round little lenses make things look much bigger than they appear to the naked eye. So he went to a spectacle maker and learnt lens grinding. He burnt the midnight oil and people thought he was crazy because he worked far into the night just to make the tiniest lenses he possibly could. He would then mount these tiny lenses on oblong pieces of copper, and even silver and gold. He made hundreds of them in order to look at the muscle fibres of a whale, or the scales of his own skin. Sometimes he would lop off the head of a fly so as to find out what it would look like under his improvised microscope.

That was not all. He would examine a specimen, keep it aside, perhaps for months, and then look at it again so as to note the changes which had occurred. This Dutchman had spent about twenty years at his work when it was noticed by a scientist named Graff who persuaded him to report his findings to a newly formed society known as the Royal Society of England. Actually this was a college whose members included the two great scientists, Newton and Boyle. Graff made the 'crazy' Dutchman describe all that he had seen through his lenses and our Dutchman went on making lens after lens. He looked through them at anything he came across, till one day—and that was a great day for the world—

he focussed his lens on a clear drop of 'pure' water and, presto!, the drop of still water became an ocean in which there swam an entire population. There was life and movement in the myriads of little things, all within the limits of a single drop of water!

Yes, that was the day when Leeuwenhoek discovered microbes. Let us here give his own words to his daughter Maria on this great discovery. "Come here, look! There are little animals in this rain-water! They swim! They play! They are a thousand times smaller than any creature we can see with our naked eyes alone."

Later he wrote about this moment, "Of all the wonders I have discovered in nature, this is the greatest. I must say that I have never known so pleasant a sight as that of thousands of these small creatures living in a drop of water, stirring as one group, yet each having its own individual movements." Just imagine! He discovered all this with his one and only tool : a piece of brass with a lens in the shape of a sphere and fitted with a fine pointed shaft for holding an object near the lens—such was the primitive microscope our Dutchman used.

What a discovery! This humble cloth merchant opened up a fantastic world visible only to the microscopic eye—a world hidden from men, a world populated with teeny weeny savages and assassins who took lives by thousands and who, if allowed to have their way, could wipe out the entire human race.

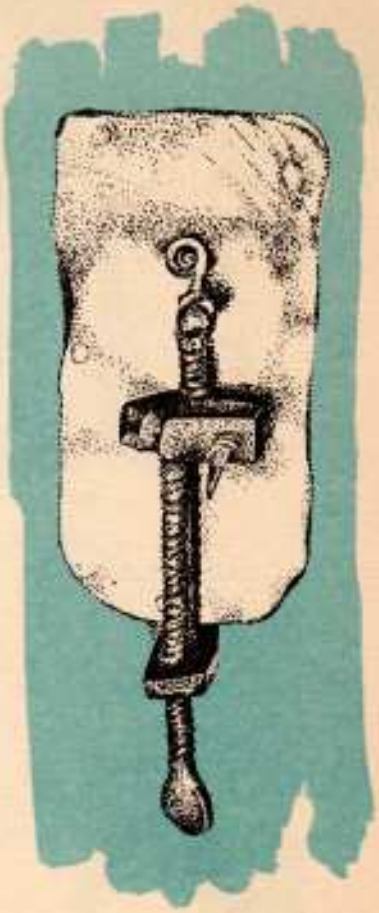
The Dutchman's excitement grew daily. "Here they are again," he would exclaim as he looked at drop after drop of water through his lens. "Here they are again—but these are of a different kind. Wait! Here is a third kind." All this he said as he saw the tiny creatures of different shapes and sizes dashing, twirling and twisting about.

When the Royal Society members heard about the Dutchman's discovery they made similar microscopes to test how far the 'crazy' Dutchman was right. "Yes, sir," they exclaimed, "he is absolutely

right!" Leeuwenhoek had not lied even later when he said, "These tiny beasts are everywhere, even in my mouth!" He had observed microbes from his mouth even though he used to clean his teeth with salt and water and, at the age of 50, had a well-preserved set of teeth. One day he scraped off "the white stuff" between his teeth and mixed some of it with pure water. He looked at this through his famous microscope and, lo and behold!, he saw tiny creatures, some leaping and whirling, some tumbling over, some moving about sluggishly. "Good Lord!" he exclaimed, "my mouth is full of them!"

And so, Leeuwenhoek came across these tiny creatures in the rain drop, in his mouth and later in his discharges when he had a spate of loose motions. But, poor Anthony, he did not guess that these tiny creatures he saw in his stools were, perhaps, themselves responsible for his troubled tummy.

Anyway, years rolled by but he could not show or prove to the world that human diseases were due to these microbes. At last, at the ripe old age of 91, the Dutchman died. He left such a legacy of knowledge that it was later possible to prove that human diseases were due to these microbes. It was a



LEEUWENHOEK

French chemist named Louis Pasteur who nearly a century and a half later launched the theory that some of these microbes could invade the body of an animal or of a human being and cause disease.*

We can now sum up the Dutchman's contributions to science as follows :

1. He discovered that there was what he called a SUB-VISIBLE WORLD to see which our eyes needed special help. He was the first to discover microbes.

2. He could not tell whether the teeny weeny creatures he saw through his lenses were friends or foes, nor did he bother about it; and yet, his contribution to science was indeed great.

Don't you think so?

* * *

PASTEUR

The microscope has come a long way since Leeuwenhoek ground his wonderful lenses. The microscope is today a fairly complicated instrument. The best optical microscopes today available magnify objects 1,400-1,500 times. Red blood cells magnified a thousand times seem

* You can read the exciting story of Pasteur's life and work in No. 5 of this series: *Pathfinders in Science—1—LOUIS PASTEUR.*

to be one-quarter of an inch in diameter and the structure of animal and plant cells can be studied. The shape of many bacteria can be clearly discerned as rods or dots.

However good the lenses, no optical microscope is useful for magnifying objects more than 1,500 times. This is because light waves are about one-fifty-thousandth of an inch in length, which prevents objects smaller than that from being seen clearly. This difficulty was overcome to some extent by using 'short-wave', ultra-violet light which we cannot see but which affects photographic plates, thus making highly magnified photographs possible. However, this took microscopists only some way ahead as they were again limited by the wave-length of ultra-violet light. The difficulty was overcome by the electron microscope which uses beams of electrons, minute sub-atomic electrified particles, instead of light. These cannot, of course, be focussed by ordinary lenses. This is done by powerful electromagnets and, since we cannot see electron beams directly, the final image is thrown on a viewing screen or made to fall on a photographic plate, both of which are sensitive to electron beams.

3. Koch, The Microbe Killer

"I HATE this bluff that medical practice is!" said a young doctor in despair, and he had reasons to say so. He could not cure his child patients of a deadly disease known as diphtheria. Why? Because no one knew what caused it. Let us see what he said further on this subject. "It is not that I do not want to save babies from diphtheria but that I cannot. Mothers come to me crying, asking me to save their babies and what can I do?"

This fumbling, groping doctor was no other than the famous Robert Koch who was one of the poineer hunters of those teeny weeny microbes that are the foes of mankind.

And yet this simple doctor, who ultimately saved humanity from diseases like pneumonia and T. B., did not want to become a doctor at all. He was dreaming of being an adventurer and wanted to hunt tigers but, instead

of tigers, was destined to hunt the tiniest of deadly creatures, the microbes.

Let's learn more about Koch. It is the year 1860 and we now go to Germany where we see a young man courting his girl friend Emmy. But the maiden refuses to marry him until the young lover settles down to his medical practice. Emmy won, for Koch began his practice. Restless as he was, he went from village to village, and so it came about that on his 28th birthday, young Dr. Koch happened to be in a Prussian village. It sounds strange, but it was on this 28th birthday that things changed for Koch. His wife Emmy's gift on that day made Koch turn to a new field of study. The gift was—can you guess what? Well, never mind if you cannot—but if you could, you would perhaps guess that it was a microscope. Koch liked it very much, and he began to get a lot of fun out of it! What fun, indeed! He began examining almost anything that came his way until one day . . . .

That was a crucial day, indeed, when he looked through his plaything at a drop of black blood from a dead sheep! Yes, a dead sheep! How did the sheep die? Ah! there begins another story.

In this Prussian village, the simple

farmers were harassed by a mysterious death that killed off their whole herds of cattle and sheep. This disease which worried the poor farmers was known as ANTHRAX and the circumstances under which these sheep and cattle died were always the same. They would see a sheep frisking about one day, and the next day? Lo! it was as stiff as wood and cold as ice with all its blood turned black! Animal after animal met the same fate and then one day when a farmer had lost his entire flock it would be his turn to fall ill with a disease like pneumonia and, before help could reach him, he himself would die a swift death.

Here was Koch's opportunity. He examined a drop of blood from an anthrax victim, and what did he see? Strange stick-like objects. A few of these short sticks stuck together and formed long threads. Koch was curious to know whether these sticks were alive or whether it was just that the diseased blood clotted into little sticks and threads. Soon he, like our friend Leeuwenhoek the Dutchman, was called crazy—indeed so 'crazy' that he would forget to sign his prescriptions. He became so absent-minded that he forgot his duties towards his devoted wife and even towards his patients. He was bent on finding out

what these little sticks and threads, were, ands he partitioned his little room and, except when he was practising, he stayed behind the partition and devoted himself to experimenting with the drops of the black blood under his microscope. Finally he experimented with living things like white mice. There sat our friend with his microscope amidst the cages of these poor creatures. He injected a drop of the black blood into the tails of the white mice, only to find them dead a few hours later with their legs stiff and turned up. This was proof enough that the black blood was poisonous and that it killed the poor mice and therefore the cattle as well.

But was that proof complete? What about the sticks and threads? Where were they? He cut open the swollen spleen of a dead mouse and put a drop of its blood under his microscope and what did he see? The sticks and threads! There they were, hundreds of them! Nay, myriads of them! Koch wondered, "I put only a few hundred sticks into the mouse's body. Then how is it that there are now billions of them within just 24 hours? Where on earth did they come from?"

One could write pages on what Koch did with his microscope and his determination to probe into the mystery of the deadly sticks and threads. But to put it in a nutshell, times out of number he put a few of these sticks into a drop of liquid from the eye of an ox to prove finally that these sticks were really alive and did grow in number. In one such drop, he delicately inserted the tiniest fragment of the spleen of a mouse that had died of anthrax. Within hours the piece of spleen was covered with myriads of these sticks and threads.

Indeed, these sticks were the tiny foes of the sheep and the cattle. They were really the bacteria about which we talked so much in the first chapter and these particular ones which have the shape of rods, sticks or threads are called BACILLI—the assassins of these poor animals. When Koch discovered this fact, he is reported to have said, "A bacillus is a million times smaller than an ox, and yet,

when it gets into an ox, it grows into millions choking the animal's blood vessels and swarming into the creature's lungs and brain." So this was the cause of anthrax, the disease that wipes out herds of sheep and cows and can attack even man if he breathes these 'sticks' from his animals into his lungs where they cause a disease like pneumonia.

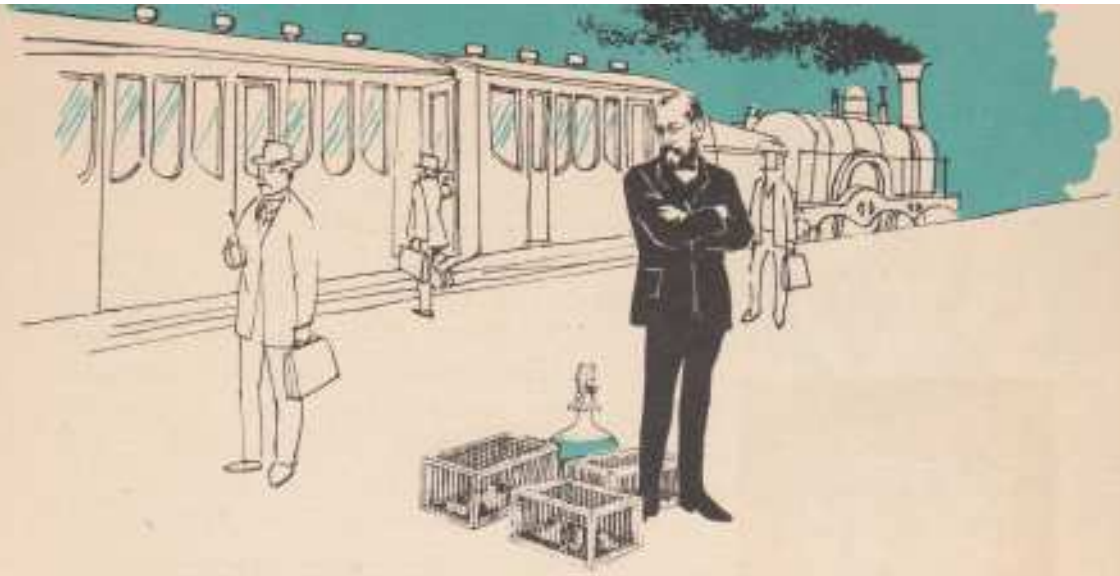
4. Caught At Last

THE QUESTION of questions that worried our friend Koch was: How on earth do these anthrax bacilli from sick animals get into healthy ones? He was determined to find a solution to this problem. What he did was to examine a tiny piece of spleen full of anthrax bacilli under his microscope. He watched and watched until the little microbes grew dim. Later they broke up and almost faded from view. In other words, he watched the blood from the diseased spleen until it dried up and then he brought one of his friends, a white mouse, out of its cage and injected the dried blood into it, only to find that it had no effect at all on the mouse. It seemed that the microbes had died within two days, while the injected mice moved about merrily in their cages. Then one day he

noticed a strange thing. When he again viewed the drop, he saw changes occurring in those thread-like microbes. The threads became less visible and in them were seen shining bead-like tiny objects. "Wonderful!" he exclaimed. "How did the beads get inside the threads? Anyway, isn't it strange that the bacilli that made threads have now changed into strings of beads?"

He put these dried beads away for over two months and even after that long a period, when he viewed them again through the microscope, the strings of beads were still there. But yet later on, a greater wonder awaited him when he placed a drop of pure fluid from an ox's eye on a glass plate smeared with the dried blood. As soon as he did that, what do you think happened ?

Well, Koch was shocked and surprised to see these beads change and grow back into the ordinary bacilli. So from threads to beads and back to threads! Actually, when the blood dried up, the bacilli in it turned into what are called spores and these spores in a dead animal's body managed to remain alive seven months after the animal died. What was worse, as mentioned above, the moment he put the beads into a drop of ox's eye fluid or even injected them into



the tail of a rat, these spores could hatch out into deadly bacilli.

It is said that Koch was so sure of his discovery that he thought of declaring it at a conference to the scientists of Europe. He put on his best suit, wore his gold-rimmed spectacles, and packed his only luggage—cages full of mice and glass cells containing anthrax bacilli! He boarded the train to Breslau. At the conference, he handled his mice and the drops so confidently that it did not take long for the scientists to admit that Koch had, after all, discovered the root cause of the scourge that killed the cattle. What is more, for the first time, he showed the way of destroying these bacilli and preventing their growth.

"To stamp out this terrible disease," he declared to that august assembly of scientists, "we will have to go all out to destroy the carcasses of animals that die of anthrax and that too without delay."

"How should we go about it?" asked one from the audience.

"They must be buried deep: indeed, very, very deep in the ground, or burnt completely."

And so, the fight against the enemy of sheep, cattle and even man began.

Well done Mr. Koch, well done indeed!

Koch, however, was not so easily satisfied. He turned his attention to another sly murderer much smaller than the anthrax bacillus. Here was another enemy of man. Indeed so deadly was this enemy that it killed one man, woman and child of every seven that died each year and it had spread throughout Europe and America. The disease caused by this bacillus was known as Tuberculosis, popularly called T. B., and the only thing the doctors knew about it was that it was caused by a germ that could be transmitted from a sick patient to a healthy person.

This was the starting point for Koch. He injected scores of rabbits and guinea pigs with material from the dead bodies of people who died of tuberculosis. These poor animals naturally developed T.B. and Koch went on examining their tissues under his microscope for days on end but he could see nothing in them.

He thought of an idea. "May be, it's tricky to spot this germ as it is. Why not colour the tissue with a powerful dye," said Koch to himself, "and then I could probably trace the tubercule germ."

At last he was successful. One day he saw under his microscope tiny red-coloured rods among the ruined lung cells of

a dead workman. These rods were not straight and thick like the anthrax germs. They were slender and had little bends and curves.

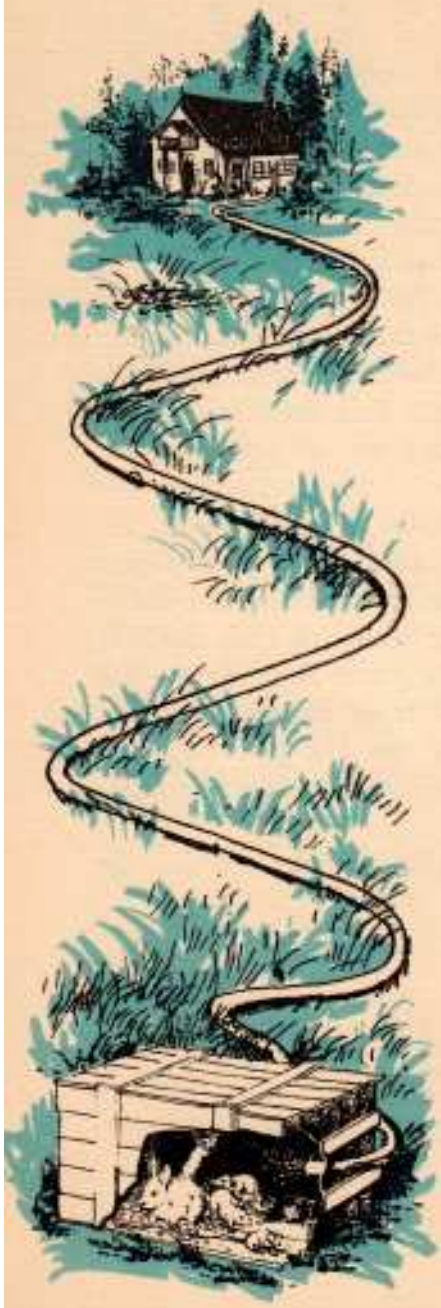
By now the poor animals which he had injected were dying a slow death, after being reduced to mere skin and bones. Koch promptly stained the tissues of the dead animals and found the same type of terrible rods—what is worse, from one little dot of tubercular material in the animal, the bacilli had multiplied into millions. So Koch had discovered the bacillius that caused T.B.

Now he set upon the task of finding out how this bacillus made its way into the lugs of a healthy person. He came to the conclusion that, since human lungs were the usual abode of these bacilli, it was easy to guess that human beings caught this dreadful disease by inhaling these bacilli, perhaps from dusty air, or perhaps from the coughing of consumptive poeople.

But to make sure of this, he hit upon a novel idea. He made a big wooden box and put mice, rabbits and guinea pigs in it. He then took a garden hose and actually sprayed these bacilli from his laboratory into the box, pumping them in with the help of a pair of bellows. The poor animals, for three long days—half an hour each day—could not but inhale these poisonous bacilli, and after ten to twenty-five days, one by one the poor creatures where dead. Indeed, what greater proof could one need to establish how human beings caught T. B. bacilli?

And now comes the finale, the last of the drama on which the curtain rings down.

THE PLACE: Berlin
THE YEAR: 1882
THE DAY: March 22
THE OCCASION: A Special Meeting of the Physiological Society, Berlin.



Yes, sir! The stage was set. A galaxy of scientists was waiting for the anxious moment. A small man with his gold-rimmed spectacles was about to declare to the world of scientists that he had at last caught the culprit that sapped the lives of thousands throughout Europe and Asia. Koch with his papers in his shaking hands read out how he had studied the habits of this dreadful bacillus, where it was usually found and how it could be fought. There was pin-drop silence followed by well-deserved and thunderous applause for the great discoverer.

Koch, the hunter, had at last tracked down the culprit!

* * *

Robert Koch had identified the bacteria which cause anthrax and TB. But the quest of science is endless and with each problem solved a dozen others spring up, demanding solutions.

Koch had discovered the germs causing anthrax and TB. He had also thrown considerable light on how these diseases spread and this helped in devising measures to prevent their spread. But the problem of curing persons once they were attacked by these diseases had yet to be

solved. The reaction of the body to attacks by germs and the body's natural defence mechanism had still to be fully investigated though, by Koch's time, means had already been discovered, in the cases of some diseases, of building up immunity to attacks of certain germs. The age of "wonder drugs", of "chemoterapy" was round the corner, but plenty of hard work had still to be done. But all this was built on the foundations laid by pioneers like Koch and others in the 19th century.

5. The Microbe Tribes

THANKS TO scientists like Koch and the Dutchman Leeuwenhoek, we are now familiar with our teeny foes, viz. the germs or rather the microbes. These living creatures, which we see through the microscope, were thought to be animals and this view persisted for a long time. Now that we are going to describe the tribes in this chapter, let us remember that most of them are very, very tiny, and it is only the colonies that they form which are large enough for us to see with our naked eyes.

Let's see where we find them. In water ?—Yes, indeed! In the air?—Of course! Indeed, for that matter, where not? They are found in the bodies of plants and animals. If you go up into the mountains, you'll find them there—yes, in the snow too. If you go deep into caves, you are bound to come across them there as well.

Does this mean they exist everywhere? No, there are places where they simply cannot exist. They are killed by extreme heat and even by extreme cold. Bright sunlight is their Enemy No. 1, lack of moisture is their Enemy No. 2, and any harmful chemical is their Enemy No. 3, for they can wipe them out completely.

Scientists tell us that although there are thousands and thousands of varieties of microbes, they can be broadly described as belonging to certain definite types. Let us briefly describe them.

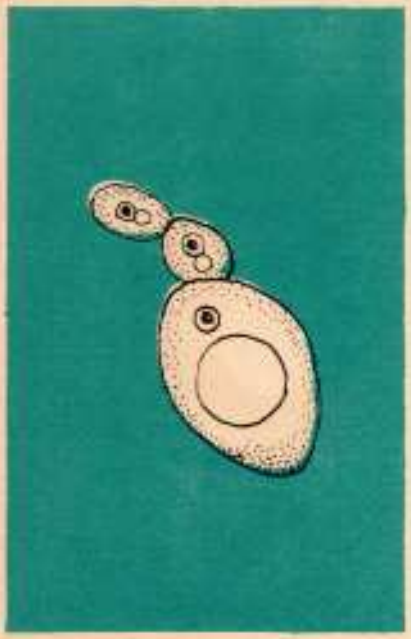
TYPE I : BACTERIA

This is the most important group of microbes. They are tiny one-celled plants of various sizes and shapes. What are these shapes?

(A) The first shape is like a ROD. We call bacteria of this shape *bacilli* (pronounced, ba-si-lie), singular *bacillus.*

(B) The second shape is like a BALL. We call bacteria of this shape *cocci* (pronounced, kok-sigh), singular *coccus*

(C) The third shape is like a CORK-SCREW. We call bacteria of this shape



spirilla, singular ***spirillum***.

It is interesting to note that the first two types, viz. bacilli and cocci, are sometimes grouped together in bundles and sometimes in chains. Look at the illustration on the previous page and you will recognise the three shapes easily.

TYPE II : YEASTS

This is the second group of microbes. Bakers, and your mother perhaps, make use of a type of yeast for raising bread. This yeast is therefore a friend of mankind. But there are other types which are disease-causing germs and are, therefore, foes.

TYPE III : MOULDS

A mould is a plant but it is not always a single cell; it often has a body made of many cells.

It is necessary to remember here that the three types of microbes mentioned above, viz. bacteria, yeasts and moulds, are all plants, but there are one-celled animals too. Do you know PROTOZOA?

TYPE IV : *PROTOZOA*

Although these are one-celled, they

are of different sizes and shapes. Do you know where they live? In one drop of water you'll find hundreds and thousands of them huddled together.

TYPE V : VIRUSES

The four types of microbes mentioned above are not the only ones that trouble mankind. The most common foe that harasses you and me is the culprit that causes the common cold— a VIRUS. Viruses are even smaller than the tiniest bacteria and can be only see through a special microscope known as the Electron Microscope. Viruses grow only in a living cell.

There is yet another type :

TYPE VI : RICKETTSIA

In size these microbes are between the viruses and the bacteria. They too grow only in living cells and cause a lot of damage to human beings.

Now let us also think of our teeny weeny friends ; for only those microbes that cause disease are called germs. There are other microbes which are quite harmless and some of which are even helpful.

Some of them help in making cheese. Some make alcohol—so important in the chemical industry.

The most important and helpful bacteria are those that help in the decay of dead plants and animals. You will ask, "How does that help us?" We know how important it is for our soil and air to get back the materials which green plants use to make food. Decay is the process which disintegrates dead plant and animal tissues into simpler substances which plants can absorb from the soil.

Protozoa too are useful in as much as they provide food for some larger animals. These larger animals in turn are eaten by fish which we human beings use as food. Isn't that wonderful? We feed on fish, the fish feed on protozoa, protozoa feed on bacteria and so, ultimately, the fish-eaters depend upon these bacteria. This is how some of the microbes are useful and hence friendly.

Before we say goodbye to these teeny weeny foes and friends, let us learn something about how they multiply.

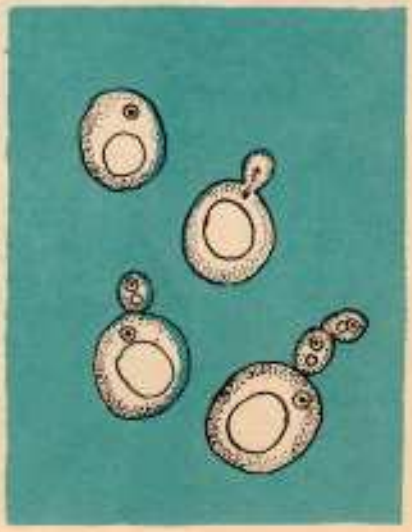
We'll talk about bacteria first. Whether they are bacilli or cocci or spirilla, they all reproduce the same way. Let's begin with one bacterium (the singular for bacteria is bacterium) which has, of course, a one-celled body. When this

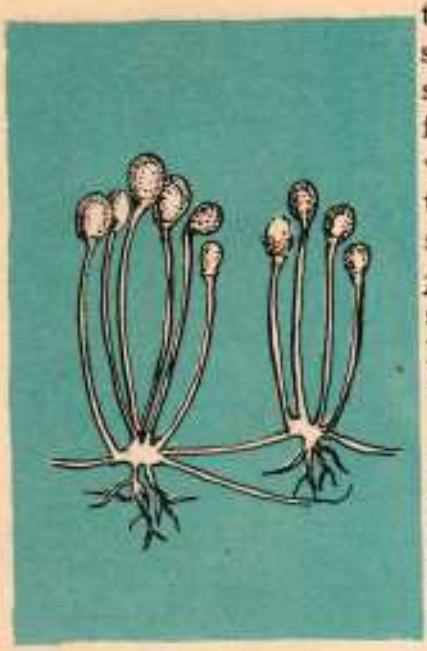
one-celled body divides into two we get two bacteria, just like the first one, which also have one-celled bodies. So there are now two cells where there was one before and each of these cells is a complete bacterium. In the beginning, the size of the two new cells is small, but, under favourable conditions, they grow to full size. Now, in their turn, each of these two subdivide into two each, and so there are four bacteria, and this goes on and on. But remember, they multiply in a matter of minutes. Why, millions of them are born in just a few hours! Can you believe that?

So wonderful is nature that not all the microbes multiply in the same way. Take for example, the yeast microbes. They too are one-celled but they reproduce in another way. What the yeast plant does is to push out a part of its body. This part though small in the beginning grows as big as the first one. It breaks off and puts forth more small buds which, together, may start the formation of a colony.

How do moulds multiply?

We must remember that moulds have bodies made of many cells and are therefore able to produce multiple spores and that is where they differ from bacteria among which only *individual* organisms





turn into *individual* spores on drying, each spore reviving as a single bacterium or single yeast. Among bacteria, spore-formation only serves to help the individual organism to survive adverse conditions—drying—by going into a dormant state. There is no *reproduction* or *multiplication* of individuals. The multiple spores produced by moulds, on the other hand, serve a *reproductive* purpose, i.e. *they enable moulds to multiply.*

Mould spores, like seeds, germinate to produce more new plants like the mould itself. The spores look like tiny bits of dust, and from each of these grows a mould plant. Spores may germinate within a few hours but sometimes may take years to do so.

Let us now talk about protozoa. Like bacteria, each protozoon divides itself into two. But nature is unique. Some protozoa also produce multiple spores and each spore means one new, active protozoon is developed.

Finally, the microbes that grow in living cells, the viruses which, curiously, can be made to form crystals which, by themselves, are non-living things. The rickettsia also grow in living cells.

And to end, a few more words about our tiny foes :

—certain types of BACILLI cause *anthrax*, *tuberculosis*, *plague*, *diphtheria* and *typhoid*;

—certain types of COCCI cause *pneumonia*, *scarlet fever*, and *boils*;

—a small, comma shaped SPIRILLUM causes *cholera*;

—certain types of YEASTS and MOULDS cause *skin diseases* and a *disease of the lungs*;

—certain PROTOZOA cause *dysentery* and *malaria*;

—certain VIRUSES cause *measles*, *mumps*, *chicken pox*, and *influenza*—the usual 'children's diseases'—and also *small pox*.

DOWN WITH THESE LITTLE FOES! YES, DOWN WITH THEM!

How do we destroy them?—I will tell you some other time.

You have read in this book mainly about the work of Leeuwenhoek and Koch. On p. 10, Pasteur and a book about him in this series (No. 5) have been mentioned. No 11 in the series (see opposite) deals with the work of Haffkine, a Russian scientist who worked in Bombay on defeating plague and, in No. 6, you can read abut how the blood stream plays a part in resisting bacterial invasion. To be published in 1969 in this series are a book on Jenner, who devised the system of vaccination against small pox, and in two parts, *The Conquest of Disease*.

CITIZENS OF TOMORROW SERIES

This series was inaugurated in Bombay on 6 October 1967 by Dr Triguna Sen, the then Education Minister, Government of India. Its main aim is to acquaint you with the broad principles and applications of science and technology and with the world around you and also to guide you in the choice of your career. As *The Illustrated Weekly* remarked, "these books will make your classroom lessons easier and more interesting for, in a simple and captivating manner, they deal with many scientific and educational subjects."

1. It Pulls Us All Down
2. Man from Monkey ?
3. Our Teeny Weeny Friends and Foes
4. The Mighty Atom
5. Pathfinders in Science – 1 – Pasteur
6. This Red Red Blood
7. Our Asian Brothers – 1 – Iran
8. They Protect the Nation
9. Sunward Ho !
10. The Sack that Contains You
11. Pathfinders in Science – 2 – Haffkine
12. Electricity at Home
13. The Journey of a Morsel
16. Man on the Moon

Nos. 1-12, Rs. 1.80 each; Nos. 13 & 16, Rs. 2.00 each

Forthcoming titles in the

CITIZENS OF TOMORROW SERIES

14. Our Asian Brothers – 2 – Burma
15. They Build the Nation
17. Lands of the Living Furnaces
18. Pathfinders in Science – 3 – Jenner
19. The Heart
20. The C-in-C of the Body
21. Canopy of the Heavens – I
22. Canopy of the Heavens – II
23. Pathfinders in Science – 4 – Einstein
24. The Conquest of Disease – I
25. The Conquest of Disease – II
26. The Telescope
27. The Throbbing Earth – I
28. The Throbbing Earth – II

Rs. 2.00 each